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A Warm-up Laparoscopic Exercise Improves the Subsequent Laparoscopic Performance of Ob-Gyn Residents: a Low-Cost Laparoscopic Trainer

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ABSTRACT

Introduction: Residents traditionally acquire surgical skills through on-the-job training. Minimally invasive laparoscopic techniques present additional demands to master complex surgical procedures in a remote 2-dimensional venue. We examined the effectiveness of a brief warm-up laparoscopic simulation toward improving operative proficiency.

Methods: Using a "Poor-Man's Laparoscopy Simulator," 12 Ob/Gyn residents and 12 medical students were allocated 10 minutes to transfer 30 tablets with a 5-mm grasper from point A to point B via laparoscopic visualization in a warm-up exercise. Participants repeated the exercise following a 5-minute pause. Mean scores, expressed in seconds/tablet, and overall improvement (percentage difference between warm-up and follow-up) were analyzed according to postgraduate standing (PGY1-4), dexterity skills, and pertinent vocational activities.

Results: Significant improvements were noted for both residents (+25%) and medical students (+29%), $P<0.0001$. Scores between the 2 groups, however, were not significant ($P=0.677$). Proficiency was not influenced by PGY standing. Interestingly, the best (8.73 sec/pill) and the worst (25 sec/pill) scores were attained by a medical student and a chief resident, respectively, suggesting the contribution of individual aptitude.

Conclusion: A brief warm-up exercise before an actual laparoscopic surgical procedure significantly improves subsequent laparoscopic performance.

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INTRODUCTION

One of the most important developments in gynecologic surgery during the past 2 decades has been the advent of endoscopic instrumentation and minimally invasive laparoscopic surgery. Accordingly, developing the necessary technical expertise for laparoscopic surgery is an essential component of residency training. Although laparoscopy can provide distinct advantages for the patient, including decreased length of hospitalization, decreased analgesic requirement, and a shortened postoperative convalescence, one concern has been whether laparoscopic techniques should be learned solely in the operating room.[1] The operative theater as the exclusive venue for the mastery of basic laparoscopic skills is less than efficient and is cost ineffective.[2] Experience has shown that only those who become comfortable with the laparoscopic environment are able to directly focus their attention on the surgery itself and provide optimal management for the patient and improve surgical outcome.[3] It is unfortunate that, unlike athletics or music which are practiced before an actual performance is ever undertaken, development of surgical expertise has traditionally occurred entirely in the operating room in a manner that can best be described as "on-the-job."

In the world of professional aviation, pilots rigorously hone their proficiencies with the aid of the flight simulator. Similarly, mechanical and computer-based laparoscopic simulators have been developed to meet the expanding challenges of reducing operative risk while controlling cost.[4,5] For the novice operator, training with laparoscopic simulators provides significant improvement in skill levels over a relatively short period.[6,7] Moreover, the surgical laparoscopic simulator can be a practical tool in identifying those residents who need additional surgical instruction, and it affords safe, hands-on remediation, and provides a means of certifying surgical proficiency.[8]

With the above goals in mind, we embarked on a brief pilot study to assess the influence of an elementary laparoscopy exercise on the subsequent performance of obstetrics and gynecology residents at different levels of training.

METHODS

Study Groups

The study was conducted at The Brooklyn Hospital Center in 2003. Twelve residents, 3 per each of 4 postgraduate-years (PGY), from the Department of Obstetrics and Gynecology, participated in the study exercises. Twelve third-year medical students also took part to essentially function as a control, because in contrast to residents none of these individuals had any previous experience with laparoscopy.

Laparoscopy Laboratory

A simplified "poor man's" laparoscopy chamber simulating the abdominal cavity was assembled from 2 large plastic delivery basins held together rim-to-rim with 3 large clamp-type paper clips **(Figure 1)**. Two laparoscopic ports, 5 mm and 12 mm, were inserted into the roof of the chamber. A handheld laparoscope with a miniature digital video camera on its tip (Digi Pen-II, Dual Mode USB Camera, Sharper Image, USA) was inserted through the 12-mm port. The camera was connected via the USB cable to a laptop computer serving as the laparoscopy monitor **(Figure 1A)**. A 5-mm grasper (Ethicon Endo-Surgery, Cincinnati, OH) was inserted through the 5-mm port. A glass 7.5-cm-tall bud vase with neck diameter of 2.5cm and a standard 10-cm-diameter Petri dish were affixed 11cm apart to the bottom of the laparoscopic chamber with adhesive-backed Velcro **(Figure 1A inset, Figure 1B)**. Thirty polygonal-shaped tablets (Natalcare Plus, prenatal multivitamin/mineral tablets, Ethex Corporation, St. Louis, MO) were arranged to cover the bottom of the Petri dish. The exercise consisted of transferring tablets, one at a time, under laparoscopic visualization from point A (Petri dish) to point B (bud vase) with the 5-mm grasper **(Figure 1B)**. The chamber was illuminated with a fixed light source. As in the actual laparoscopy setup, our setup required 2-hand coordination: one hand operating the scope, the other the laparoscopic grasper.

Rehearsal, Warm-up, and Follow-up Exercises

Because grasping, lifting, and transferring of the polygonal-shaped slippery tablets with a 5-mm laparoscopic grasper has proven to be very challenging, the participants were allowed to familiarize themselves with the experimental setup during 5 minutes of rehearsal, transferring the tablets from petri dish to bud vase under direct visualization with the lid of the laparoscopic chamber removed. Following the rehearsal, each participant performed 2 laparoscopic exercises; a warm-up (baseline) and a follow-up exercise conducted subsequent to a 5-minute respite. Each participant was allotted 10 minutes to transfer as many tablets as possible. Both warm-up and follow-up exercises were timed. The elapsed time (seconds) for each of the participants to complete the above task was divided by the number of tablets transferred from point A to point B and expressed as an elapsed time quotient (seconds/tablets). For those who did not complete the task, ie, transferred less than 30 tablets in the prescribed 10 minutes, an alternate score expressing the actual number of tablets transferred during the 10-minute period was assigned. Overall improvement was expressed as the percentage difference (warm-up - follow-up)/

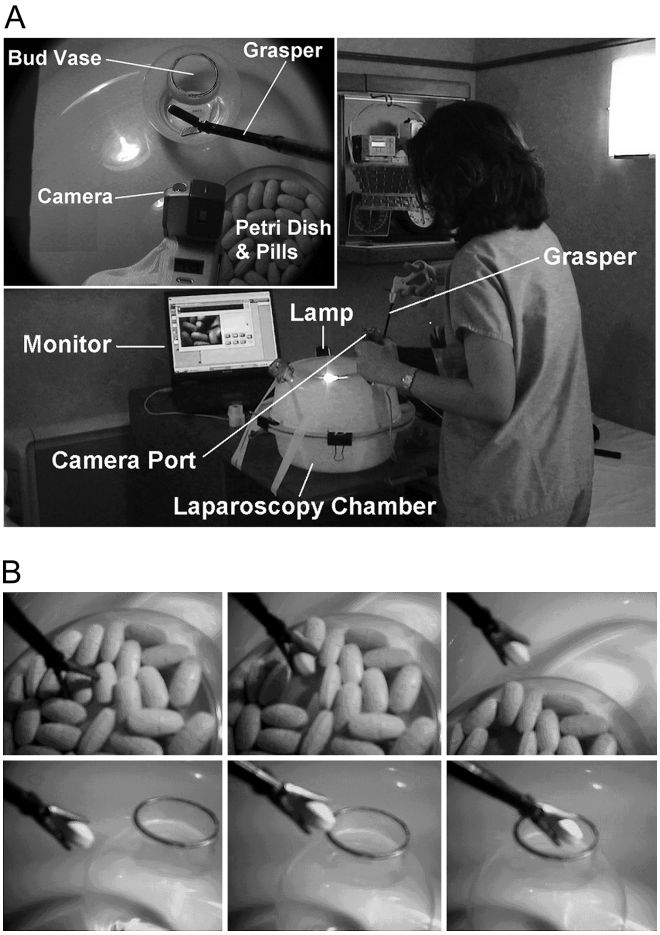

Figure 1. Experimental Setup. **Figure 1A** shows study participant performing a laparoscopic exercise. The upper left insert shows the chamber with the lid removed. **Figure 1B** consists of 6 successive frames showing grasping, lifting, and transferring the tablet from the Petri dish to the bud vase.

warm-up x 100) between exercises. All results are presented as mean ± standard deviation (SD).

Statistical Analysis

Exercise scores and pertinent information regarding postgraduate standing, undergraduate background (technical or liberal arts), and vocational activities were entered into a PC Excel spreadsheet (Microsoft Corp, Redman, Washington). Statistical analysis was conducted using Analyse-it statistical software for Excel (Analyse-it Software, Ltd., Leeds, England, UK). Independent sample *t* tests were used to compare warm-up verses follow-up between residents and medical students, while paired sample *t* tests were conducted to assess overall proficiency improvement within the 2 groups. Additionally, analysis of variance (ANOVA) was conducted to determine the influence of level of postgraduate training on laparoscopic proficiency. Statistical significance was determined at 0.05.

RESULTS

Laparoscopic proficiency scores, ie, the time needed for the task to be completed, as reflected by reductions in the mean seconds/tablet measurements of the follow-up exercises, indicated that both residents and third-year medical students benefited from the warm-up simulations. Overall laparoscopic performance **(Figure 2A)** was significantly improved for both residents (all years combined) and the medical student control group ($P<0.0001$). The mean elapsed times (sec/tablet) for warm-up and subsequent follow-up exercises for each of the individual resident postgraduate years and the students **(Figure 2B)** clearly indicate comprehensive reductions in times for all study subgroups. The percentage difference (improvement) between warm-up and follow-up exercise elapsed times by graduate standings is given in **Figures 3A and 3B**. The overall performance of the residents (all PGY) improved by 25%. Likewise, the medical students' performance was improved by 29.3%. The difference between the 2 participating study groups was not significant ($P=0.216$).

Table 1 gives the mean number of seconds per tablet of warm-up and follow-up exercises for both residents and medical students. Albeit not statistically significant, residents were slightly faster than the medical students during the initial warm-up exercise ($P=0.861$). The relationship reversed during the follow-up exercise, where the medical students actually gained proficiency over the residents (16.26±3.98 vs 17.02±4.72 sec/tablet). These differences

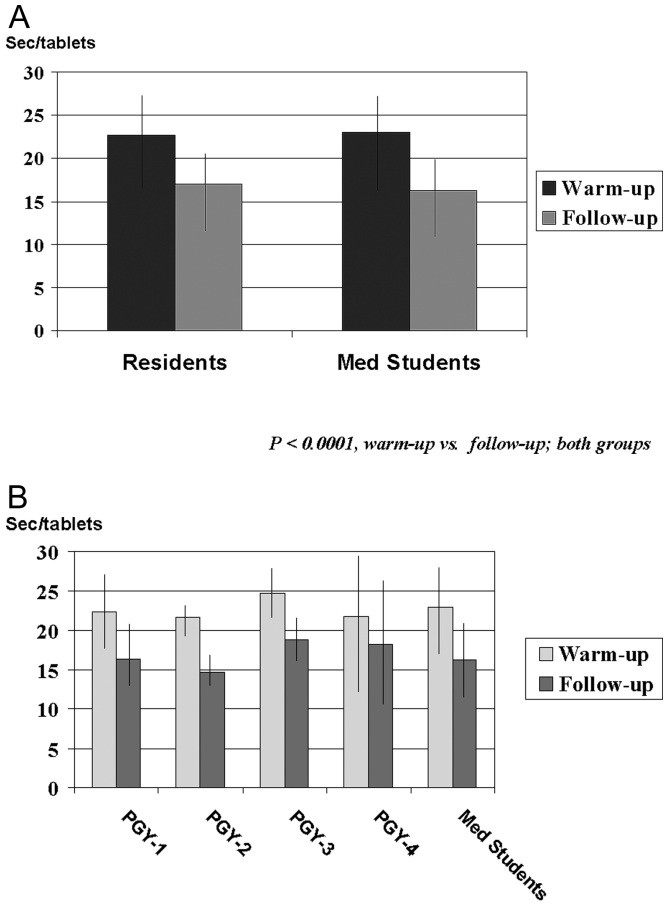

Figure 2. Residents' and medical students' performance during warm-up and follow-up exercises (expressed in number of seconds required to transfer one tablet from point A to B given as mean ± SD. **Figure 2A** shows comparative overall performance of residents (all PGY) and medical students. **Figure 2B** compares the residents at each postgraduate year of training along with the medical students.

also were not, however, found to be statistically significant ($P=0.677$).

Table 2 gives the overall mean elapsed times in resident test score proficiency among all PGY levels. Significant improvements were once again noted in follow-up verses warm-up elapsed times ($P=0.015$) **(Figure 3A)**; however, no statistical differences existed in overall proficiency between each year of residency training ($P=0.689$). When comparing exercise scores between the PGY levels, second-year residents improved the most (32.3%), followed by the first (27.2%) and third year (23.6%). Interestingly, at 17.3%, the senior residents exhibited the least improvement **(Figure 3B)**.

Table 1.
Mean Elapsed Exercise Times (*sec/tablet*)

	Warm-up	Follow-up	Mean Difference	% Difference	*P*-Value Difference	*P*-Value Groups
Residents	22.63 ± 5.20	17.02 ± 4.72	5.61	25%	0.0112	0.861
Students	23.01 ± 5.25	16.26 ± 3.98	6.47	29%	<0.0001	0.677

Table 2.
Summary of Resident Laparoscopic Proficiency: Mean Elapsed Times (*sec/tablet*)*

PGY	Mean	SD
1	19.34	5.21
2	18.21	4.05
3	21.75	4.34
4	19.99	8.23

*P value between test type = 0.015; P value between PGY status = 0.689.

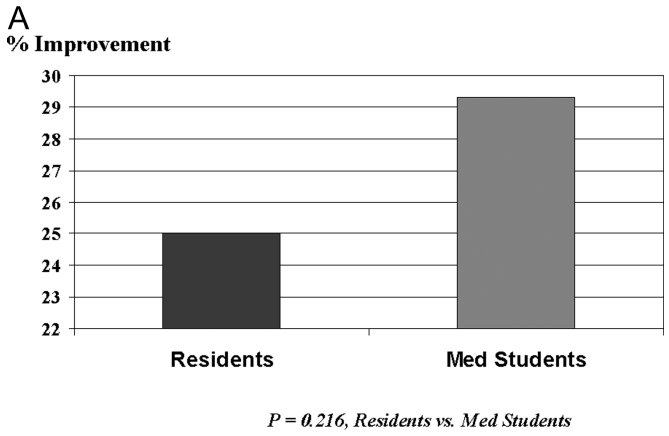

Figure 3. All participants improved during the second (Follow-up) exercise. The chart illustrates the percentage improvement for all residents and medical students **(Figure 3A)** and for each individual postgraduate training year **(Figure 3B)**.

No apparent differences in laparoscopic proficiency were found between individual technical background or lack thereof, or vocational activities.

DISCUSSION

The present study was conceived as a pilot feasibility exercise to examine the potential value of endoscopic simulation in improving resident operative proficiency. The traditional approach in developing surgical proficiency has been one of didactic interchange between the preceptor and apprentice and "on-the-job training." The advent of minimally invasive surgical techniques, possessing significantly steeper learning curves has placed greater demands on the physician in training in mastering the surgical skills necessary in a remote 2-dimensional operative environment. Clearly, laparoscopic training using simulated tasks on a video-simulator improves the operative performance. Previous studies have shown that basic skills achieved by systematic training with laparoscopic simulators can be transferred to the operating room, suggesting that surgical curricula should contain laparoscopic skills training.[9] Intensive repetitive training improves video hand-eye coordination, which in turn translates into improved operative performance.[2]

Contrary to studies demonstrating a significant correlation between PGY levels and training proficiency,[10] we found no such distinctions in performance between resident standing, nor did technical background (or lack thereof) or computer skills present a definitive advantage. However, our rudimentary laparoscopic exercise did uncover slight divergences in levels of residency training and exercise score proficiencies, in that the more junior residents benefited the greatest from warm-up practice activity. This was further underscored by the similar results witnessed of the third-year medical students in comparison with their senior counterparts. Interestingly, the best (8.73 sec/tablet) and the worst (25 sec/tablet) exercise scores were attained by a medical student and a chief resident, respec-

tively, suggesting the contribution of individual aptitude. Such observations also may be attributable to the presence of latent iniquitous habits developed and carried over by some of the more advanced study participants.

CONCLUSION

Although the fundamental exercise of point-to-point transference of tablets does not provide the fidelity of a living tissue environment, laparoscopic operative simulations afford a cost-effective, risk-free adjunct to a more conventional hands-on training approach. The study did demonstrate, however, that a brief warm-up laparoscopic exercise, as performed in our "poor man's laparoscopic surgical simulator," can significantly improve the subsequent performance of both the novice operator or more advanced surgical practitioner, regardless of their previous experience and exposure to endoscopic surgical technique. Clinically, the reduction of operative duration and subsequent patient risk alone would no doubt reduce intraoperative morbidity and mortality.

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